Finite Element Analyses of the Reworked Microcalorimeter Support Stand at the SST Beamline

(Vault File: 'PD-SST-MCAL-CALC-1001.docx')

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Summary

Structural finite element analyses were performed on a reworked microcalorimeter (MICROCAL) support stand from the Spectroscopy Soft and Tender (SST) Beamline located at 7-ID at the NSLS-II. The support stand is a repurposed stand from the NSLS facility. It was reworked to accommodate a 3° vertical beamline angle at the SST beamline. Since the microcalorimeter is also supported at the ends by adjacent beamline structure, the exact load supported specifically by the stand is not known. A conservative range of 500-1000 lbs. was used in the analyses.

Results show minimal deformation and low maximum stress for the range of loads analyzed. The reworked stand is acceptable to use in its intended function.

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1. Introduction

The scope of this project is to perform structural finite element analyses on a reworked microcalorimeter (MICROCAL) support stand for the Spectroscopy Soft and Tender (SST) Beamline located at 7-ID at the NSLS-II. The support stand is a repurposed stand from the NSLS facility. Originally it was used as the U7A microcalorimeter support stand. It was reworked to accommodate a 3° vertical beamline angle at the SST beamline. The stand is located at approximately Z=56.48 m and X=2.17 m from the source.

A detail view of the Inventor model of the MICROCAL assembly from the NSLS showing the original stand before rework is given in Figure 1(A) (assembly number PD-SST-MCAL-1000.iam). A model of the reworked stand is shown in Figure 1(B) (assembly number PD-SST-MCAL-1001.iam). A closeup of the reworked section is shown in Figure 1(C). The original column was cut in two pieces, machined at a 3° angle, and welded back together.

A model of the stand at the SST beamline is shown in Figure 2. It is evident that the MICROCAL is also supported upstream by the end of the I0_UP section, and supported downstream by the beampipe connected to LARIAT I. Therefore, the reworked stand only supports a portion of the total weight of the MICROCAL. The exact portion of weight supported is unknown, so a conservative range of 500-1000 lbs. is used in the analyses.

All analyses are performed using ANSYS Workbench Version 18.2.

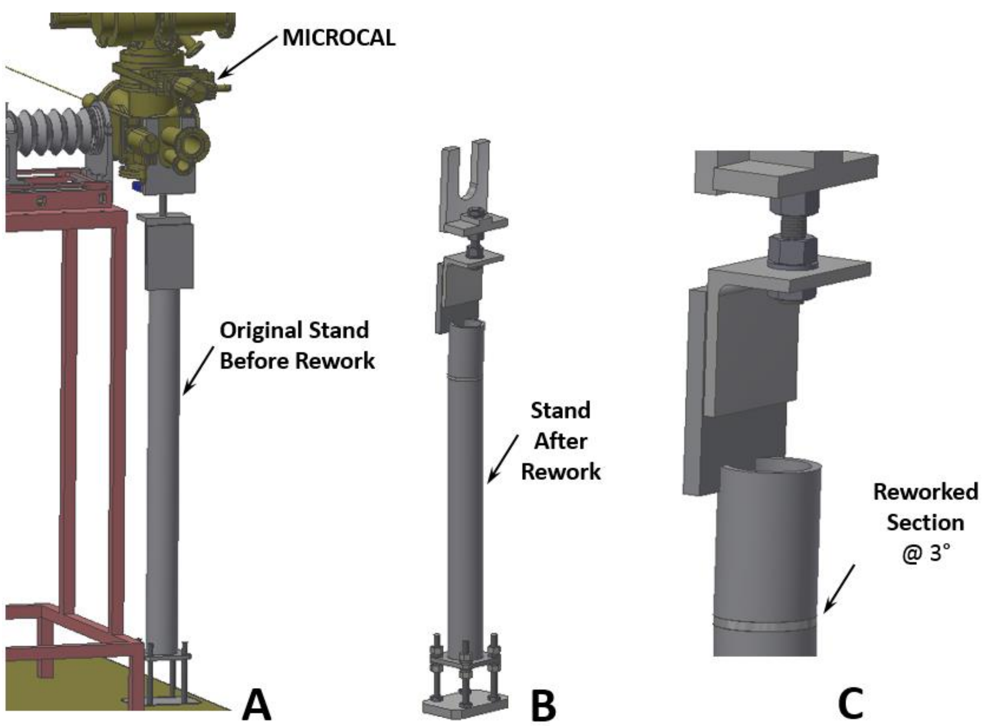

Figure 1. MICROCAL Support Stand. (A) Original Before Rework, (B) Stand After Rework, (C) Detail of Reworked Section

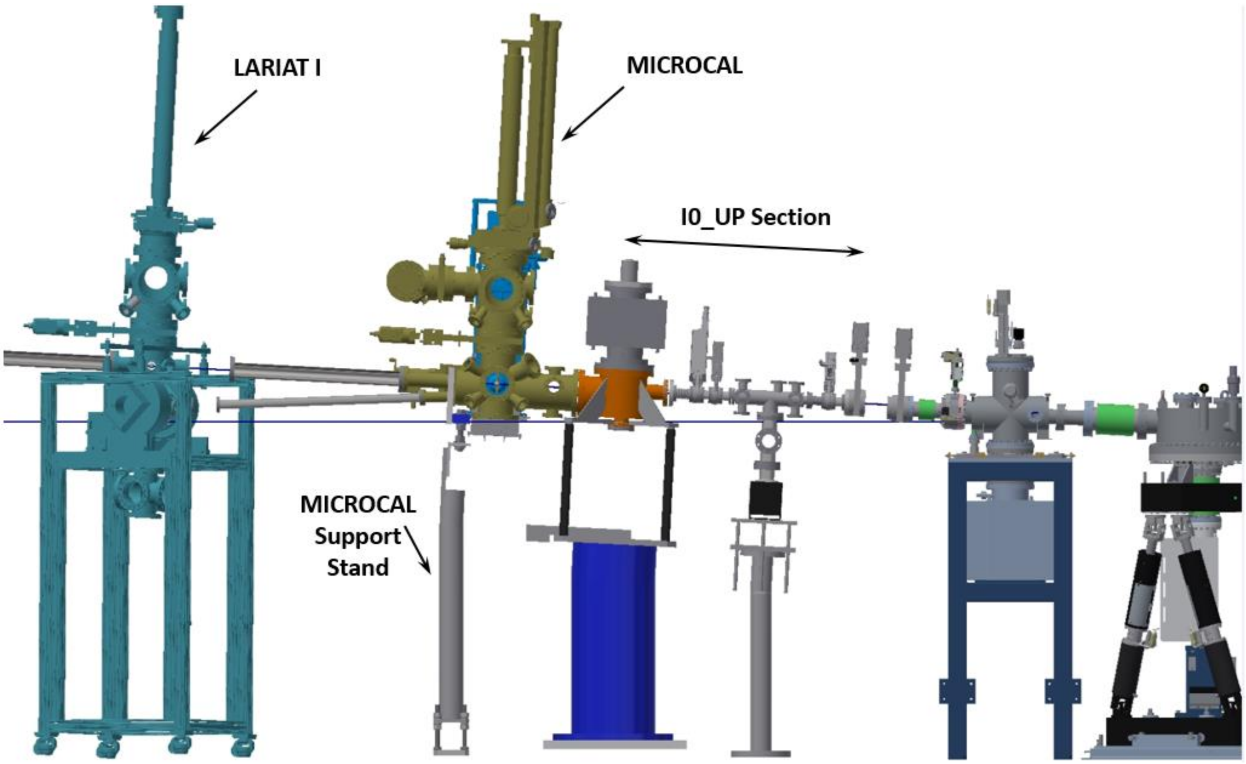

Figure 2. SST Beamline Section Showing Microcalorimeter (MICROCAL) Support Stand

2. Analysis Parameters and Setup

2.1 Model

Minimal changes were required to prepare the model for finite element analysis. Five-millimeter fillets were added between the top of the column and the connecting plate to simulate the weld bead.

2.2 Material Properties

The material specifications of the stand are not available, so the exact grade of steel used is unknown. (This is a repurposed stand from NSLS.) It is therefore assumed that the material is standard structural steel. Material data was taken from the ANSYS Engineering Data Source Materials Library and is given in Table 1.

Material	Density [kg/m^3]	Young's Modulus [Pa]	Poisson's Ratio	Tensile Yield Strength [MPa]
Structural Steel	7850	2.0E+11	0.3	250 MPa

Table 1. Material Properties

As will be shown in the Results section, high tensile stress occurs in the 1" diameter threaded rod located near the top of the support. This threaded rod is likely made from high strength steel. However, since the material is not known for certain, structural steel is assumed to be conservative.

2.3 Mechanical Loading and Supports

A model detail of where the upper portion of the support stand is connected to the MICROCAL is shown in Figure 3(A). As can be seen, the load is applied to the stand through a bolted plate. To simulate this in the finite element model a load surface is defined as shown in Figure 3(B). The weight load is vertically downward, at a 3° angle to the surface. A fixed support boundary condition is used on the lower surface of the bottom plate (not shown), which is in contact with the floor.

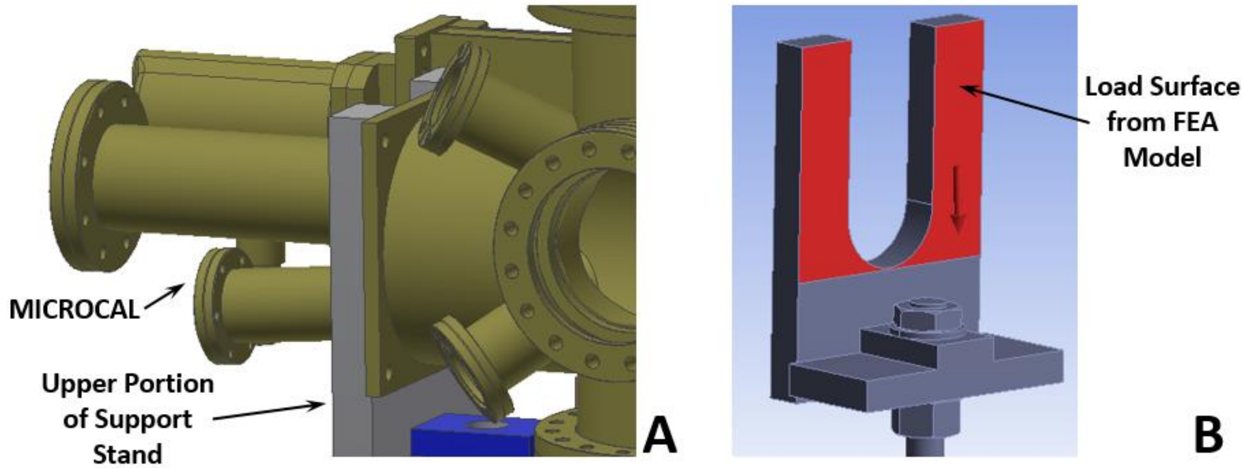

Figure 3. (A) Support Stand – MICROCAL Connection, (B) FEA Load Surface

2.4 FEA Mesh

Care was taken to ensure that enough elements were used in the areas of high stress and through the thickness of the column. As will be shown in the results section, the high stress area is at a location indicated by the orange box in Figure 4(A), which is the upper portion of the support stand. A close-up of the mesh in this area is shown in Figure 4(B).

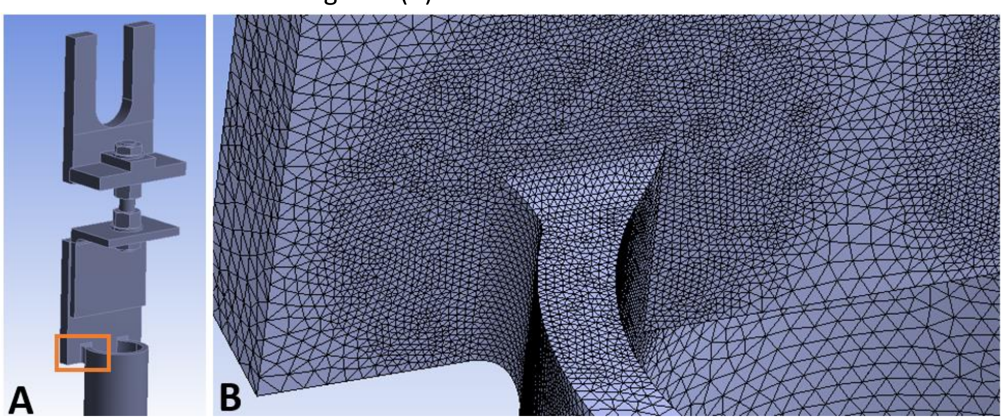

Figure 4. (A) Upper Portion of the Support Stand with the High Stress Area Indicated by the Orange Box; (B) Finite Element Mesh in this High Stress Area

3. Results

3.1 Results Summary

Table 2 gives a summary of the results. The area of highest stress is at the interface between the upper column section and connecting plate, as shown in Figure 5. The maximum stress occurs in the fillet area between the bodies. The point of maximum stress is at a sharp edge between model fillets. Since there are no sharp edges in the physical part, the stress concentration will be absent, and the maximum stress in the physical part is expected to be lower than the calculated value. (It is difficult to model a smooth transition here as Inventor automatically creates the hard edge when fillets are added.) Table 2 also includes the maximum stresses in the upper column section and connecting plate. Graphical results of the deformation and stress are presented in Section 3.2 for the case of a 500 lb. load (results from the 1000 lb. load are qualitatively similar).

While the maximum stress occurs at the interface between the upper column section and the connecting plate, the stress here is compressive and will not encourage crack growth. Also of interest is the almost pure tensile stress at the elongated surface of the bent threaded rod as indicated in Figure 5, which shows the top of the stand in its deformed state. Table 2 also gives the stress results in the threaded rod. For the threaded rod, the normal stress in the vertical direction is considered rather than the von Mises stress because normal stress is a better representation of pure tensile stress in the rod.

In all cases the maximum stresses are well below the yield stress (250 MPa) for the given loading (which is conservative).

Load (pounds)	Load (Newtons)	Max Deformation	Max Stress (von Mises)	Max Stress in Upper Column (von Mises)	Max Stress in Plate (von Mises)	Max Compressive Stress in Threaded Rod (Normal)	Max Tensile Stress in Threaded Rod (Normal)
500 lb.	2224.1 N	0.26 mm	52.3 MPa	37.7 MPa	28.3 MPa	50.2 MPa	37.1 MPa
1000 lb.	4448.2 N	0.51 mm	104.5 MPa	75.4 MPa	56.6 MPa	100.4 MPa	74.1 MPa

Table 2. Results Summary

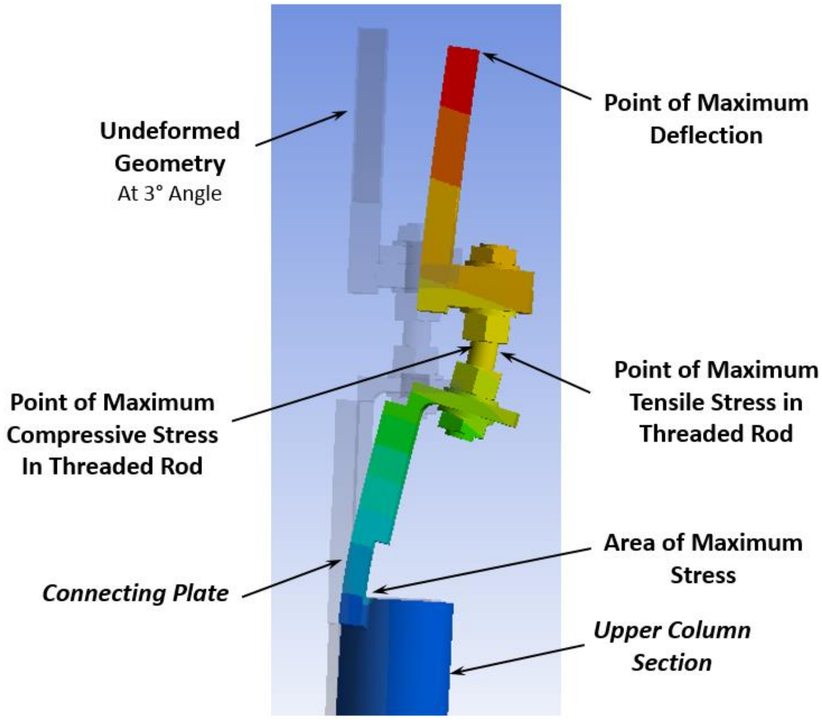

Figure 5. Detail View of Upper Portion of the MICROCAL Support Stand in its Deformed Position (Undeformed Geometry is shown in Grey)

3.2 Graphical Results

The total deformation of the full support stand and three areas of interest are given in Figure 6. The graphical deformation is highly exaggerated for clarity. Figure 7(A) shows the stresses in the full support stand and Figure 7(B) shows a close-up of the area of maximum stress, which is at the interface between the upper column and the connection plate. Figure 7(C) again shows the stresses in the upper column and connection plate, but with the fillets hidden from view. Figure 8 shows the normal (tensile) stress in the upper threaded rod assembly.

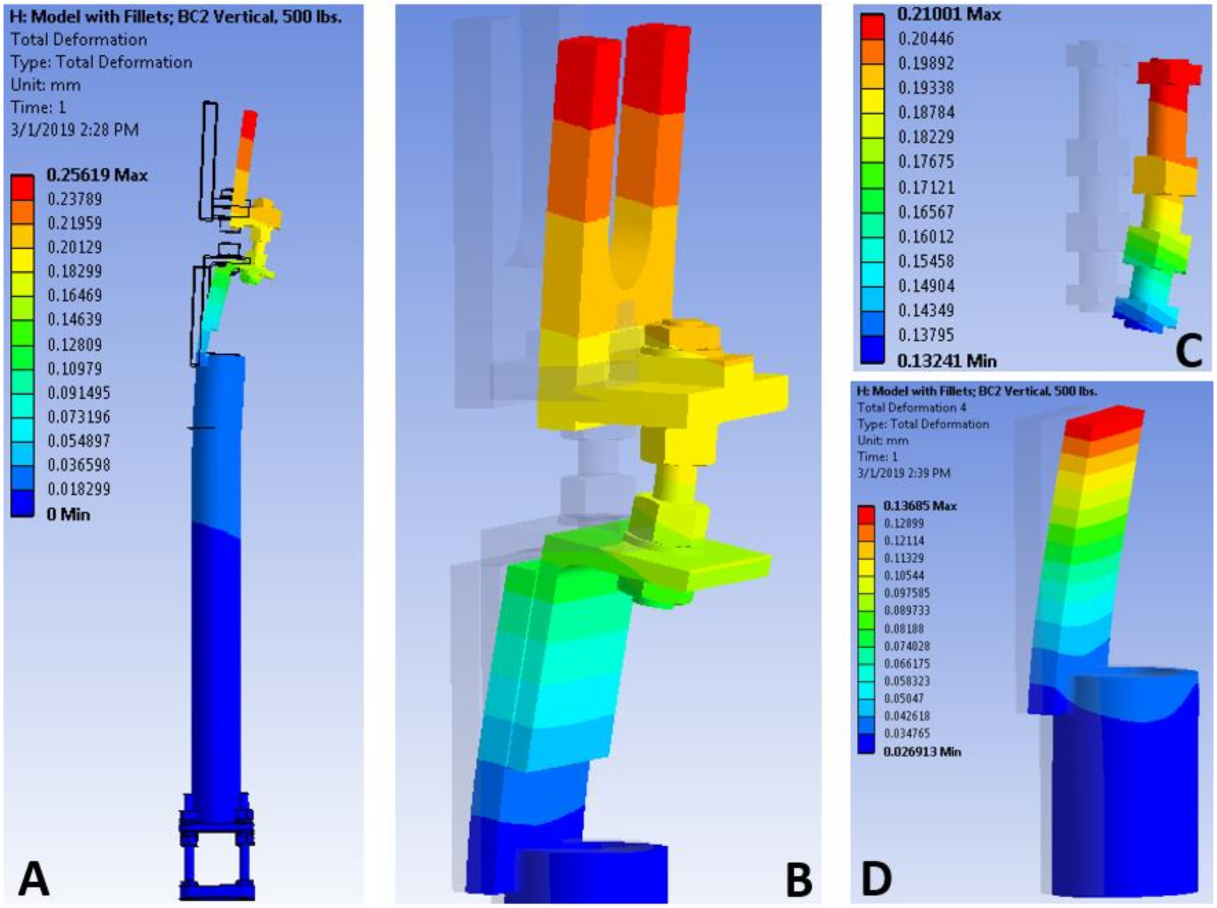

Figure 6. Total Deformation (Load = 500 lbs.):
(A) Full Model Deformation (Undeformed Geometry Shown as Wireframe);
(B), (C), (D) Deformation at Areas of Interest (Undeformed Geometry Shown in Grey)

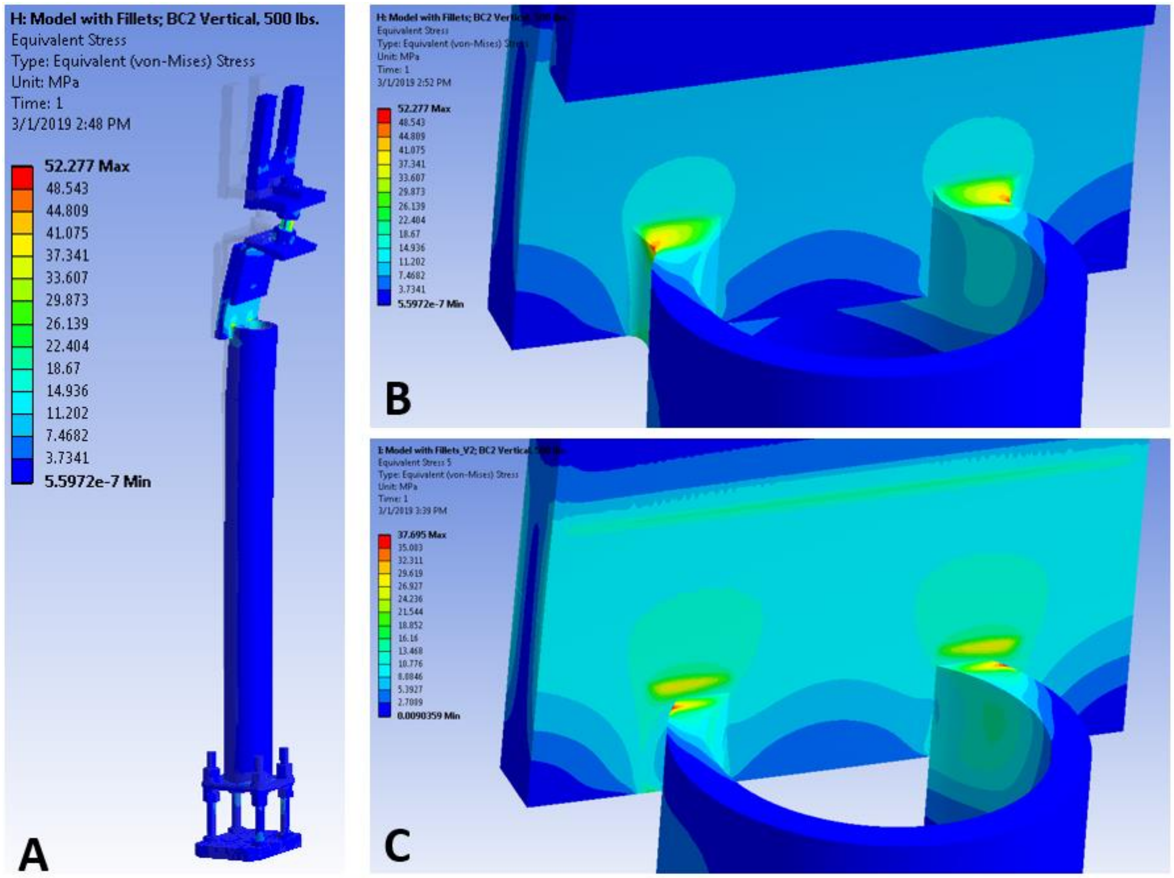

Figure 7. Stress Distribution (Load = 500 lbs.)
(A) Full Model Stress (Undeformed Geometry Shown in Grey); (B) Close-up of High Stress Area,
(C) Close-up of High Stress Area with Fillets Hidden from View

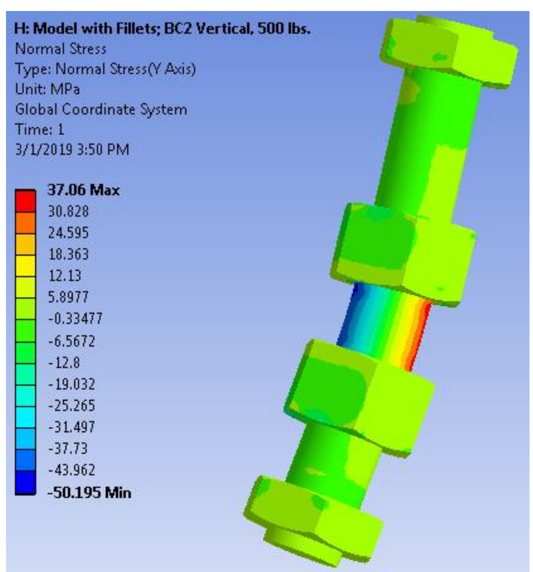

Figure 8. Normal (Tensile) Stress Distribution in Threaded Rod

4. Conclusions

Structural finite element analyses were performed on the reworked microcalorimeter support stand from the Spectroscopy Soft and Tender (SST) Beamline located at 7-ID at the NSLS-II. The support stand is a repurposed stand from the NSLS facility. Originally it was used as the U7A microcalorimeter support stand. It was reworked to accommodate a 3° vertical beamline angle at the SST beamline. Because the beamline components are supported at several locations, it is difficult to determine exactly how much weight the stand itself is supporting. A conservative range of 500 to 1000 lbs. is assumed.

In all cases the maximum stresses are well below the yield stress for the given loads. The reworked stand is acceptable to use in its intended function.